

is an element except for fluorine atom and F is fluorine, and the total number of fluorine atoms in elements constituting said gas molecule is four or less.

REMARKS

This is a full and timely response to the final Official Action mailed July 9, 2002. Reexamination and reconsideration in light of the following remarks are courteously requested.

Claims 1, and 4 to 6 are currently pending for the Examiner's consideration following entry of the amendment. Although after a final Office Action, the present amendment is compliant with Rule 116. The amendment does not raise new issues as the amendment is merely the incorporation of the canceled claims into the independent claims, verbatim.

Further, the total number of pending claims is reduced, and the amendment places the application in condition for allowance, or at least in better condition for appeal, as the amendment clarifies how claims would stand or fall together.

In the Action, the Examiner rejected claims 1 to 3 under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 6,146,542 issued to Ha et al. ("Ha") in view of U.S. Patent No. 5,164,330 issued to Davis et al. ("Davis"). The Examiner also rejected claims 4 to 8 as being unpatentable over Ha in view of Davis and U.S. Patent No. 6,296,780 ("Yan"). These rejections are respectfully traversed.

The arguments previously made of record acknowledge that the present invention is directed to the use of a very particular combination of gases for the purpose of dry etching a metal having specific properties such as those of tungsten, and for making a semiconductor apparatus using the same combination of gases. The present amendment adds more particularity to the etching gas component of the gas mixture. Particularly, the amendment to claim 1 establishes, as claims 2 and 3 previously established, that the ratio of fluorine to carbon in the fluorine-containing gas is four or less, and that the total number of fluorine atoms in the molecule is less than 4.

It has been argued, and the Examiner appears to have conceded, that although the Ha patent teaches a combination of gases for etching tungsten, Ha's combination fails to specifically teach that a dry etching mixed gas includes a fluorocarbon. The Examiner also appears to agree that the Yan patent fails to compensate for the deficiency of the Ha patent in this respect. Consequently, in order for the present invention to be rendered obvious, there must be some teaching somewhere in the prior art that the SF₆ and/or NF₃ gases in Ha's etching gas combination could be replaced by a carbon-containing fluoride gas that conforms to the definitions newly included in claim 1.

* → Davis clearly fails to suggest such a replacement. The

Examiner asserts in part 4 of the Office Action that Davis's disclosure of carbon-containing fluoride compounds establishes that the claimed fluorocarbon compounds are known, and that knowledge of the use of such compounds as tungsten etching agents is sufficient motivation for the replacement of Ha's SF_6 and/or NF_3 with a carbon-containing fluoride gas. However, it is respectfully pointed out that the only reason Davis mentions the carbon-containing fluoride gas is by way of instruction that it should not be used in an etching process. Davis teaches that inorganic fluoride compounds such as NF_3/Ar mixtures should be primarily used "to remove the bulk of a tungsten film" followed by smaller etch steps that may include fluorocarbon compounds (col. 8, lines 22 to 29).

Further, it is again emphasized that the present invention is not directed to a single etching gas, but a very particular combination of gases. The replacement of one gas for another in a particular combination of gases, like the Ha combination, must be done with some motivation, and the broad assertion that one gas is known tungsten etchant is not sufficient motivation to use it as a replacement for another gas, especially when there is no teaching or suggestion that the particular combination is in any way deficient or in need of improvement.

The Examiner cites case law that supports the argument that it is obvious "to use two compositions each of which is

taught by the prior art to be useful for the same purpose."

However, that argument is not applicable to the present rejection, as the Examiner would not have two compositions being used together, but would in fact have the fluorocarbon compounds of Davis being substituted for the fluoride compounds of Ha.

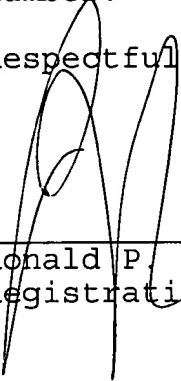
To summarize, the present invention involves using the fluorocarbon compound in a gas mixture of oxygen, nitrogen, and a chlorine or hydrogen bromide compound to remove an entire layer of tungsten, and in another embodiment, to also remove an underlayer of tungsten nitride or titanium nitride. As established above, the person of ordinary skill in the art would not find motivation in the prior art to combine the known gases in the manner that is presently claimed, and would in fact be deterred from reaching the combination due to the explicit teachings of Ha and Davis. Consequently, the claims are not obvious, and the rejections of claims 1 to 8 should be withdrawn.

For the foregoing reasons, all the claims now pending in the present application are believed to be clearly patentable over the prior art of record. Accordingly, favorable reconsideration of the claims in light of the above remarks is courteously solicited. If the Examiner has any comments or suggestions that could place this application in even better form, the Examiner is requested to telephone the undersigned

attorney at the below-listed number.

Respectfully submitted,

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APPENDIX

Amendments to the Claims

1. (amended) A dry etching method comprising the step of:
dry-etching tungsten using only a single mixed gas
including a fluorine-containing gas that includes a compound
having fluorine and carbon in a molecule, chlorine or hydrogen
bromide, oxygen, and nitrogen,

wherein said fluorine-containing gas has a structure that
a ratio of fluorine atoms with respect to elements of the gas
molecule except for fluorine is four or less when the
composition of the fluorine molecule is M_xF_y , $Y/X \leq 4$ where M
is an element except for fluorine atom and F is fluorine, and
the total number of fluorine atoms in elements constituting
said gas molecule is four or less.

4. (amended) A method of manufacturing a semiconductor
apparatus comprising the steps of:

laminating upwards a polycrystal silicon film or an
amorphous silicon film, a tungsten nitride film or a titanium
nitride film, and a tungsten film on a silicon substrate; and

performing a dry-etching of said tungsten nitride film or
said titanium nitride film and said tungsten film with only a
single mixed gas containing fluorine-containing gas that
includes a compound having fluorine and carbon in a molecule,

chlorine or hydrogen bromide, oxygen and nitrogen so that a gate electrode is formed,

wherein said fluorine-containing gas has a structure that a ratio of fluorine atoms with respect to elements of the gas molecule except for fluorine is four or less when the composition of the fluorine molecule is M_xF_y , $Y/X \leq 4$ where M is an element except for fluorine atom and F is fluorine, and the total number of fluorine atoms in elements constituting said gas molecule is four or less.